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ABSTRACT

This paper presents two examples in which technology, in this case a fairly sophisticated authoring system--ToolBook, was used as a tool to construct student understandings in mathematics. In doing so, students were able: (1) to successfully identify the variables (unknowns) and the information given (data) in the problem; and (2) to create meaningful links between the data and givens which enable successful problem solution. Examples are from work in a seventh grade pre-algebra class of below-average-ability students in a middle class urban setting and are from a single classroom. (Author/MKR)

A Constructivist use of Technology in Pre-Algebra

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A CONSTRUCTIVIST USE OF TECHNOLOGY IN PRE-ALGEBRA

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This paper will present two examples where technology, in this case a fairly sophisticated authoring system - ToolBook, was used as a tool to construct student understandings in mathematics. In doing so, students were able: (a) to successfully identify the variables (unknowns) and the information given (data) in the problem; and (b) to create meaningful links between the data and givens which enable successful problem solution.

These examples were from work in a seventh grade pre-algebra classroom of below average ability students in a middle class urban setting and are from a single classroom. The curriculum used was conceptually based and utilized a five phase approach which allowed students to construct mathematical intuition via physical materials and computer use (Connell, 1994, Connell and Peck, 1993).

In this method, the initial two phases require use of physical materials to present problems and actively engage students with the materials to model mathematical situations, define symbols, and develop solution strategies. The third phase uses sketches of physical materials and situations experienced by the students to encourage a move toward abstraction. These student sketches, many of which were constructed using the object based graphics of ToolBook on the computer[1], then serve as the basis for additional problems and as referents for thinking. In the fourth phase, the children construct mental images through imagining actions on physical materials and manipulating the computer sketch. Following these experiences students construct arithmetic generalizations and problem solving skills through scripting their understandings using ToolBook[2].

This sequence might be visualized somewhat like Figure 1 which, although not complete, does capture the *look and feel* of the approach fairly well (Wirtz, 1979; Connell, 1986).

	Memory/Recall	Teacher Posed Problems	Self Posed Problems
Manipulatives			
Sketch			
Mental Picture			
Abstraction			

Figure 1. Simplified model.

[1]It is interesting to note the parallels between the mathematical objects these students created and the objects of analysis mentioned by Sfard and Thompson (1994).
[2]I have found HyperCard on the Macintosh works equally well. The key is not in the type of computer, but rather in how it is used.

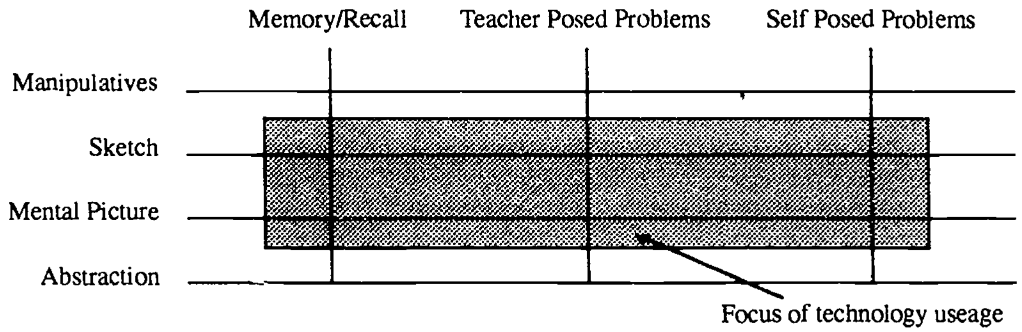


Figure 2. Focus of technology use.

This approach was implemented using an object oriented computer authoring language, ToolBook in this case. The nature of this language allowed for a wide range of powerful tools, such as drawing and painting, to be available for student use, and yet still had relatively simple syntactic requirements conducive to expressions in algebraic terms.

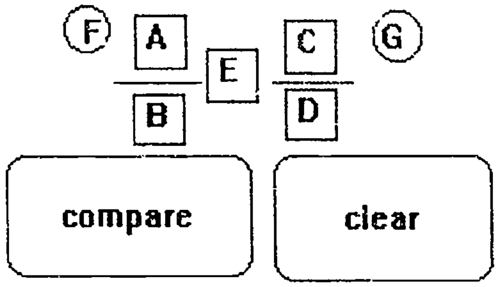
Students did work on computers until immersed in their problems via physical materials. Students commonly developed initial working representations on the computer and identified what the relevant information should be through creating appropriate input and output fields. The developing representations at this time had features common to both sketches and mental pictures. Abstraction began as they constructed their method of procedure and expressed it in algebraic terms by scripting buttons. I think of this usage of technology as providing for student construction of a bridge between sketch and abstraction as shown in Figure 2.

The computer acted as a tool and an active listener doing what it was told, not as an instructor requiring a specific answer. This "tool" helped students identify variable(s) and information (data) necessary for problem solution and to construct appropriate linkages. The student representations on the computer reflected their own ongoing construction of meaning. Family resemblances were observed in observing student work. First, students began by using the sketch tools to create a working sketch. This seems to indicate a tight linkage between the curriculum and the technology. Second, with sketch in place, students created and named fields corresponding to variables. This appears to have been highly helpful in their thinking. Third, buttons were scripted linking fields and solving the problem. The drawing tools of ToolBook and the ability to create almost any representation appeared to liberate student thinking and contributed to a natural integration of computers in the classroom.

Two student examples

These two examples illustrate how the scripting of computer objects created an entry point into the algebra. In presenting these, several modifications were necessary. First, colors were changed to black and white (originally they were highly colorful) Students learned about paint options quickly. Second, field names

are indicated to aid discussion. Lastly, spacing was added to scripts to discuss the function of each section. The examples were originally for students' use so formatting and annotating were not high priority. All else is as it was.



Example 1. *Comparison of fractions*. This tool was created after a review of fractions during which the cross-multiply method emerged. It is highly unlikely that this was a spontaneous creation - most likely it was a "rediscovery" or a "remembrance" of old learning.[3] The example shows how the students used ToolBook, however, and provides examples of scripting.

The first thing was to lay out the problem space using fields and graphic objects. As shown, the fields used by the student have been labeled **A - G**. The buttons, **compare** and **clear**, were then added and scripted to solve the problem.

```
to handle buttonup
    put the text of field "A" into a
    put the text of field "B" into b
    put the text of field "C" into c
    put the text of field "D" into d

    put d*a into the text of field "F"
    put b*c into the text of field "G"
    put the text of field "F" into f
    put the text of field "G" into g

    if f>g then
        put ">" into the text of field "E"
    end if

    if f<g then
        put "<" into the text of field "E"
    end if

    if f=g then
        put "=" into the text of field "E"
    end if
end buttonup
```

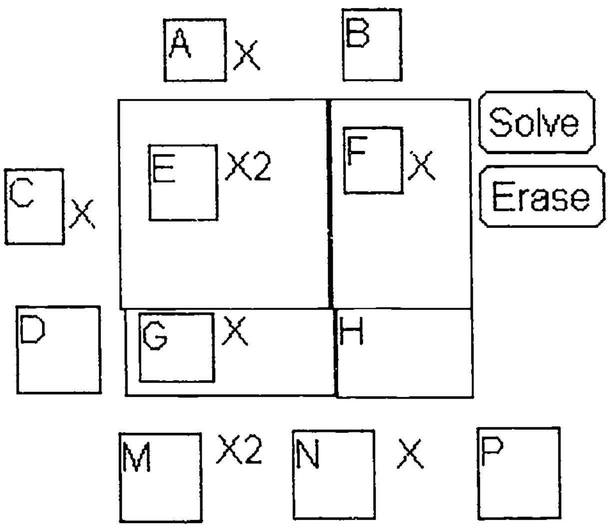
The scripting for the button **compare** is shown. The script breaks down into some well defined sets of instructions bracketed between the *to handle buttonup* and *end buttonup* statements. These tell the button to execute these instructions when clicked.

1) The student first assigns variables (a, b, c, and d) which correspond to the fields **A - D** used for input by the comparison tool.
2) These variables—containing values input when using the program—are used in calculation of values which are placed in fields **F & G**.
3) Logical conditions are then checked to see which of the comparison symbols (<. > or =) is to be placed in field **E**.

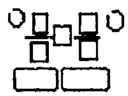
[3]This is not to say that students are incapable of constructing this method. For a discussion of one class in which students *did* construct this method see Peck and Connell, 1991.

The button **clear** was a much easier task and merely required a blank, or " ", to be placed into each field where either a character or numeral might be. This proved to be of such great utility that a version of **clear** soon became common in each of the student created tools. This illustrates creation of new objects by combining features of previously created objects. This not only enabled the **clear** button to migrate, but also allowed for the tools themselves to be shared and used by the entire class.

```
to handle buttonup
    put " " into the text of field "A"
    put " " intc the text of field "B"
    put " " into the text of field "C"
    put " " into the text of field "D"
    put " " into the text of field "E"
    put " " into the text of field "F"
    put " " into the text of field "G"
end buttonup
```



For example, the student who created the tool shown here made a copy of it and shrank it down very small - like this shown here.



Then when needed, the student would select it, expand it to useable size, and then shrink it back when it was no longer needed. It was not uncommon to see created tools of various types throughout any given "page".

Example 2. *Multiplication of binomials.* The similarity of approach students brought to bear between these two examples is easily seen. As in the fraction tool, the first thing done was to lay out the problem space using fields and graphic objects.

In the sketch shown the fields used by the student have been labeled **A - H, M, N, & P**. Original field names were not nearly so terse. Snoopy, Wimpo, and REM all ap-

```
To handle buttonup
    Put the text of field "A" into a
    Put the text of field "B" into b
    Put the text of field "C" into c
    Put the text of field "D" into d

    Put a*c into the text of field "E"
    Put c*b into the text of field "F"
    Put a*d into the text of field "G"
    Put b*d into the text of field "H"

    Put the text of field "E"into e
    Put the text of field "F"into f
    Put the text of field "G"into g
    Put the text of field "H"into h

    Put f+g into the text of field "N"
    Put e into the text of field "M"
    Put h into the text of field "P"
end buttonup
```

peared during early experiences, but proved awkward for students to remember and took longer to type. Soon single letters were adopted.

The buttons, **Solve** and **Erase**, were then added and scripted to solve the problem. As **Erase** is a modified copy of the **clear** button it will not be described.

1) Once more, the student first assigns variables (a, b, c, and d) which correspond to the fields **A - D** used for input by the multiplication tool.
2) The student then uses these variables in calculation of values which are then placed in fields **E, F, G & H**.
3) Then, in a rather interesting piece of scripting, the student then reads the numbers which the computer has put into fields **E, F, G & H.**
4) Finally, these values are used to perform the final calculations and output necessary for the answer to be in a more useable form for the student.

Implications for mathematics education

Technology in mathematical exploration typically takes the form of a black box with only outcomes visible. Methods of solution leading to the answer and rationale for them is invisible. We must provide more than a black box giving right answers, the box must be subject to student control and exploration. The work reported in this paper illustrates an alternative to black box approaches which places the student in control of the computer. As the results clearly show, this in turn results in the student being in control of the content.

References

Connell, M. L. (September, 1994). *Making Mathematics:Teaching and learning mathematics in a technologically rich environment.* Paper presented to the 75th anniversary research symposium of the University of Illinois at Champaign Urbana. Champaign:IL.

Connell, M. L. (1986). *Conceptual based evaluation and student tracking in elementary mathematics.* Unpublished masters dissertation. p. 75-80.

Connell, M. L., & Peck, D. M. (1993). Report of a conceptual change intervention in elementary mathematics. *Journal of Mathematical Behavior. 12(4)*, 329-350.

Peck, D. M. & Connell, M. L. (1991). Using physical materials to develop mathematical intuition. *Focus on learning issues in mathematics. 13* (4), 3-12.

Sfard, A., & Thompson, P. (November, 1994). *Reification in Post Secondary and K-12 Mathematics.* Paper presented at the 16th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education. Baton Rouge:LA.

Wirtz, R. (1979). *Mathematical problem solving.* In D. M. Peck (Chair), Conceptual issues in mathematical problem solving. Symposium conducted at Department of Educational Studies. University of Utah.